N92-10954

WRINKLE RIDGE - UPLAND SCARP TRANSITIONS: IMPLICATIONS FOR THE MECHANICAL PROPERTIES OF THE DEFORMED MATERIALS.

Thomas R. Watters and Michael J. Tuttle, Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560, and Debra Simpson, Department of Geology and Astronomy, West Chester University, West Chester, Pennsylvania, 19383

Wrinkle ridge - upland scarp transitions are structures that occur at the contact between smooth plains material and highlands or uplands materials on the Moon and Mars. In the smooth plains material the structures have a morphology typical of wrinkle ridges, interpreted to be the result of a combination of folding and thrust faulting [see 1, 2]. Where the structures extend into the uplands, a distinct change in the morphology occurs. The generally asymmetric cross sectional geometry characteristic of wrinkle ridges becomes that of a one-sided, often lobate scarp. The scarp is indistinguishable from other highland/upland scarps, interpreted to be the result of reverse or thrust faulting.

On the Moon wrinkle ridge - scarp transitions occur at the margins of mare basins and extend into adjacent highlands. Examples are found in the Taurus-Littrow area of Mare Serenitatis (Lee Lincoln scarp), in western Serenitatis (West Serenitatis scarp), in the area of Montes Riphaeus and near Fra Mauro [3, 4, 5]. On Mars two examples of wrinkle ridge - scarp transitions have been found. The smooth plains (presumably volcanic in origin) of a roughly 80 km basin, in the area just northeast of Herschel basin, have been deformed into a first-order ridge [see 1]. Deformation can be trace along the trend of the ridge outside the basin into the adjacent uplands. In the uplands the morphology of the structure is clearly that of a scarp. Another wrinkle ridge - scarp transition has been found in southwestern Lunae Planum at the contact between the ridged plains material and a elevated and highly degraded unit (Fig. 1). Within the unit the morphology of the structure is that of a sharp, linear scarp. Detailed mapping of the region, as part of the Mars Geologic Mapping Program, indicates that this unit is Noachian upland material.

Although these structures are rare, they provide important insight into the mechanical properties of the deformed materials. Wrinkle ridges on the Moon and analogous structures on the Columbia Plateau [1] occur in flood basalt sequences that are emplaced as a series of extensive planar sheets or layers. Based on photogeologic evidence, ridged plains units on Mars are also interpreted to be volcanic in origin, possible akin to flood basalts. Evidence of layering in ridged plains material has also been recently discovered [6]. Individual or groups of flows in a flood basalt sequence are commonly separated by interbeds. Evidence of interbeds has been found in mare basalts [7], the Grand Ronde basalts of the Columbia River Basalt Group [8] and have been suggested to exist in ridged plains sequences on Mars [9].

A layered material may be mechanically anisotropic under conditions of deformation and the anisotropy may control the geometry of the structure. Where deformation occurs at the free surface, a layered sequence of rocks would be expected to exhibit brittle behavior and

folding will occur by slip between layers or flexural slip [10]. Of course this will occur only if the shear stress on the surfaces of the layers exceeds the frictional resistance to slip between the layers. Slip would preferentially, but not exclusively, occur between layers separated by mechanically weak interbeds. It is plausible then that the presence of layering and interbeds in the mare basalts, the CRBG and martian ridged plains have influenced, if not controlled, the style of deformation. This is being explored using finite element modeling where variable slip conditions between layers can be assigned. The lunar highlands and martian uplands, in contrast, probably lack any dominant fabric such as layering and would be expected to be mechanically isotropic. Under conditions at the free surface, a mechanically isotropic material would be expected to fail in shear resulting in reverse or thrust faulting. Wrinkle ridge - scarp transitions and the contrast between the dominant style of compressional deformation in smooth plains volcanic sequences (i.e., wrinkle ridges) and uplands (i.e., scarps) on the Moon and Mars can thus be explained by a contrast in the mechanical properties of the materials.

These results were presented at the 22nd Lunar and Planetary Science Conference in Houston, Texas, March 18-22, 1991. This research was supported by NASA grant NAGW-940 and NAGW-1172.

References:

[1] Watters, T.R., *JGR 93*, 10,236-10,254, 1988.
[2] Plescia, J.B. and M.P. Golombek, *GSA Bull.*, *97*, 1289-1299, 1986.
[3] Lucchitta, B.K., *Proc. LSC VII*, 2761-2782, 1976.
[4] Howard, K.A. and W.R. Muehlberger, *NASA Spec. Publ.*, SP-330, 31-12--31-21, 1973.
[5] Watters, T.R., Tuttle, M.J. and J. Chadwick, *LPSC, XIX*, 1247-1248, 1988.
[6] Scott, D.H., Work in progress in Kasei Valles, MTM 25052, 25057, 1991.
[7] Peeples, W.J., R.W. Sill, T.W. May, S.H. Ward, R.J. Phillips, R.L. Jordan, E.A. Abott, and T.J. Killpack, *JGR, 83*, 3459-3468, 1978.
[8] Reidel, S.P., T.L. Tolan, P.R. Hooper, M.H. Beeson, K.R. Fecht, R.D. Bentley, and J.L. Anderson, *Geol. Soc. Am. Sp. Paper 239*, 21-53, 1989.
[9] Watters, T.R., *JGR*, in press, 1991.
[10] Donath, F.A. and R.B. Parker, *GSA Bull.*, 75, 45-62, 1964.

Fig. 1. Wrinkle ridge-scarp transition located in southwest Lunae Planum.